Solve as many questions as you can

6.1a At 90°C, the vapour pressure of methylbenzene is 53.3 kPa and that of 1,2-dimethylbenzene is 20.0 kPa. What is the composition of a liquid mixture that boils at 90°C when the pressure is 0.50 atm? What is the composition of the vapour produced?

6.1b At 90°C, the vapour pressure of 1,2-dimethylbenzene is 20 kPa and that of 1,3-dimethylbenzene is 18 kPa. What is the composition of a liquid mixture that boils at 90°C when the pressure is 19 kPa? What is the composition of the vapour produced?
Correct answer $x_A = 0.5$, $y_B = 0.5$.

6.2b The vapour pressure of pure liquid A at 293 K is 68.8 kPa and that of pure liquid B is 82.1 kPa. These two compounds form ideal liquid and gaseous mixtures. Consider the equilibrium composition of a mixture in which the mole fraction of A in the vapour is 0.612. Calculate the total pressure of the vapour and the composition of the liquid mixture.
Correct answer $x_A = 0.653$, $x_B = 0.347$, $p = 73.4$ kPa.

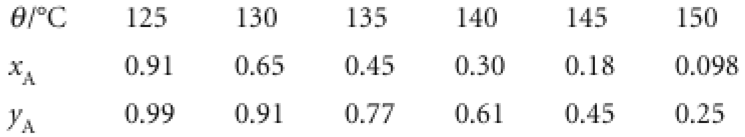
6.3b It is found that the boiling point of a binary solution of A and B with $x_A = 0.4217$ is 96°C. At this temperature the vapour pressures of pure A and B are 110.1 kPa and 76.5 kPa, respectively. (a) Is this solution ideal? (b) What is the initial composition of the vapour above the solution?
Correct Answer
(a) the solution is ideal; (b) $y_A = 0.4582$, $y_B = 0.5418$.

4b Benzene and toluene form nearly ideal solutions. Consider an equimolar solution of benzene and toluene. At 20°C the vapour pressures of pure benzene and toluene are 9.9 kPa and 2.9 kPa, respectively. The solution is boiled by reducing the external pressure below the vapour pressure. Calculate (a) the pressure when boiling begins, (b) the composition of each component in the vapour, and (c) the vapour pressure when only a few drops of liquid remain. Assume that the rate of vaporization is low enough for the temperature to remain constant at 20°C.

Correct Answer

(a) 6.4 kPa; (b) $y_B = 0.77$, $y_T = 0.23$; (c) $p_{\text{(final)}} = 4.5$ kPa.

6.5b The following temperature/composition data were obtained for a mixture of two liquids A and B at 1.00 atm,where x is the mole fraction in the liquid and y the mole fraction in the vapour at equilibrium.



θ/°C	125	130	135	140	145	150
x_A	0.91	0.65	0.45	0.30	0.18	0.098
y_A	0.99	0.91	0.77	0.61	0.45	0.25

The boiling points are 124°C for A and 155°C for B. Plot the temperature– composition diagram for the mixture. What is the composition of the vapour in equilibrium with the liquid of composition (a) $x_A = 0.50$ and (b) $x_B = 0.33$?

Correct Answer

(a) $y_A = 0.81$; (b) $x_A = 0.67$, $y_A = 0.925$.

6.6b State the number of components for a system in which $AlCl_3$ is dissolved in water, noting that hydrolysis and precipitation of $Al(OH)_3$ occur.

Correct Answer

$C = 3$.

.7a Blue $CuSO_4{\cdot}5H_2O$ crystals release their water of hydration when heated. How many phases and components are present in an otherwise empty heated container?

6.7b Ammonium chloride, NH_4Cl, decomposes when it is heated. (a) How many components and phases are present when the salt is heated in an otherwise empty container? (b) Now suppose that additional ammonia is also present. How many components and phases are present?

Correct Answer

(a) $C = 1$, $P = 2$; (b) $C = 2$, $P = 2$.

6.8a A saturated solution of Na_2SO_4, with excess of the solid, is present at equilibrium with its vapour in a closed vessel. (a) How many phases and components are present. (b) What is the variance (the number of degrees of freedom) of the system? Identify the independent variables.

6.8b Suppose that the solution referred to in Exercise 6.8a is not saturated. (a) How many phases and components are present. (b) What is the variance (the number of degrees of freedom) of the system? Identify the independent variables.

Correct Answer

(a) $C = 2$, $P = 2$; (b) $F = 2$.

6.15b Describe the phase changes that take place when a liquid mixture of 4.0 mol B_2H_6 (melting point 131 K) and 1.0 mol CH_3OCH_3 (melting point 135 K) is cooled from 140 K to 90 K. These substances form a compound $(CH_3)_2OB_2H_6$ that melts congruently at 133 K. The system exhibits one eutectic at $x(B_2H_6) = 0.25$ and 123 K and another at $x(B_2H_6) = 0.90$ and 104 K.

6.16a Refer to the information in Exercise 6.15(b) and sketch the cooling curves for liquid mixtures in which $x(B_2H_6)$ is (a) 0.10, (b) 0.30, (c) 0.50, (d) 0.80, and (e) 0.95.

6.16b Refer to the information in Exercise 6.15(a) and sketch the cooling curves for liquid mixtures in which $x(CF_4)$ is (a) 0.10, (b) 0.30, (c) 0.50, (d) 0.80, and (e) 0.95.